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Prevalence of Tick Infestations and Tick-Borne Diseases in Cattle in Cameroon

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Abstract

Ticks induce huge production and economic losses in the livestock industry and create serious environmental, animal and human health problems. The study was carried out to characterize tick species and determine the prevalence of tick infestation and tick-borne diseases in cattle in Cameroon. Tick and blood samples were collected from a total of 742 animals and analyzed to determine the type of tick and haemoparasites using standard procedures. Overall, four tick species namely *Amblyomma variegatum* (75.09%), *Rhipicephalus microplus* (19.43%), *Rhipicephalus decoloratus* (0.88%) and *Hyalomma marginatum* (0.18%) and six blood disease agents including *Anapalasma marginale* (11.29%), *Ehrlichia ruminantium* (3.52%), *Babesia bovis* (1.32%), *Babesia major* (0.44%), *Anaplasma phagocytophilum* (0.29%) and *Dermatophilus congolensis* (3.37%). Various co-infections were recorded and the predominant associations were *Amblyomma variegatum-Rhipicephalus microplus* (4.06%) and *Amblyomma variegatum-Hyalomma marginatum* (0.36%); *Anaplasma-Ehrlichia* (12%), *Anaplasma-Dematophylus* (8%), *Babesia-Anaplasma-Ehrlichia* (14%) and *Babesia-Anaplasma-Ehrlichia-Dermatophylus* (5%). Breed, sex, age and locality significantly influenced the rate of tick infestation while locality, breed and age significantly influenced the detection of blood disease agents in the study.

Keywords

Prevalence, Tick, Blood Disease, Cattle, Cameroon

1. Introduction

The livestock sector accounts for over 40% of global agricultural production and contributes to the livelihoods and food security of nearly one billion people worldwide [1]. Livestock farming plays an important role in rural Africa [2] [3], and cattle are the main savings species for smallholders. Cattle are the fastest growing sector in the agricultural economy for income growth, infrastructure and technology [4]. The cattle population in Cameroon is estimated at 8,761,385 heads, and a meat beef production of 110,000 to 145,000 tons per year is equivalent to about 54% of meat products [5].

Ticks and tick-borne diseases are major problems for human, animal and environmental health with enormous negative economic impacts and financial losses of more than $18.7 billion per year [6] [7] on beef production. Ticks are vectors of zoonoses of major public health importance [8] while tick-borne animal piroplasmosis and cowdriosis are major pathological and economic constraints on livestock development in sub-Saharan Africa [9].

Several control methods for ticks and tick-borne diseases (TBD) have been evaluated including the use of chemical products and acaricides against the vectors which pose a huge risk of drug resistance and pollution [10] [11] [12] [13]. Though the high cost of tick and tick-borne disease prevents expansion in cattle production [14] [15], vaccination is an alternative control tool in regions where there are no cross-border movements of cattle. Endogenous methods for tick control [8] [16] and other alternatives such as genetics geared towards using biological resistance mechanisms of certain species or breeds in livestock farming activities in tropical environments [17] [18] have been described.

The direct and indirect impacts of tick infestations of cattle are numerous including decreased milk productivity and carcass yield, low growth rate, the transmission of pathogens (eg. hemoparasites), dermatitis which may become infected by bacteria, skin coat depreciation making it less marketable and increase the cost of production due to tick control [19] [20] [21]. In the central African subregion including Cameroon, attention has focused on infectious and contagious diseases of animals while has neglected vector borne diseases especially tick-borne diseases [21] [22] [23].

Though there are increasing urban and peri-urban livestock production systems in most of Africa, there is a dearth of information on the level of awareness of cattle breeders on the hazards caused by ticks on husbandry systems and ectoparasite status of cattle in urban areas of Cameroon. In view of the medical and veterinary importance of ticks in the livestock sector, this study was carried out to determine the prevalence of tick infestation and ticks-borne diseases in cattle in Cameroon.

2. Materials and Methods

2.1. Study Location and Management of Animals

The study was carried out to determine the prevalence and intensity of tick infestation and haemoparasites in cattle within and around the SODEPA ranches (Livestock Development Corporation) in the Administrative Divisions of Faro & Deo (Adamawa region), Lom & Djerem (East region) in the Guinean high savannah agro-ecological zone and Donga-Mantung (North West region) in the western highland agro-ecological zone of Cameroon (**Figure 1**). The geographical and animal husbandry situations of the study regions are presented in **Table 1** and **Table 2**.

The selection of cattle herds in the SODEPA Faro, Dumbo and Ndokayo ranches and those of willing local farmers in the environs of these SODEPA ranches during the study period, May to October 2021, was done using a random number generation technique from the list herds in the area [26]. Briefly, in each ranch, two large herds from among herds in the female camps to enable sufficient sampling of adult and young animals, and two herds from among herds in the adult male camps were included in the study. All individual animals in the chosen herds were sampled. Overall, tick and blood samples were collected from 742 cattle (409 Goudali and 333 Simgoud breeds; 337 males and 405 females; 90 young, 264 juveniles and 388 adults) corresponding to 268 cattle in Faro & Deo, Adamawa, 186 cattle in Lom & Djerem, East and 288 cattle in Donga-Mantung, North-West.

Following rigorous visual examination of tick on the preferred sites of the skin of the animals (anogenital, udder, perineum, abdomen, armpit and neck) [27], all the ticks encountered on the animal's body was harvested, by gently tapping at the rostrum and traction using a pair of forceps. The harvested ticks were stored in individual 5 ml labelled (identifying the sampled animal, anatomical region, and date of harvest) tubes containing 70% ethanol and 30% glycerol for analysis within 5 - 7 days in the parasitological laboratory of the *Mission Spéciale d'Eradication des Glossines* (*MSEG*) in *N'Gaoundéré*. Systemic phenotypic identification of the tick species was done using a binocular microscope and guided by reference tick images as previously described [28] [29] [30] [31] [32].

Blood samples (5 ml) from each animal were collected by jugular vein puncture into EDTA tubes for haematological analysis (Haematocrit value) and detection of haemoparasites using standard procedures. Haematocrits were determined to assess the degree of anaemia while blood smeared slides were stained with MAY-GRÜNWALD GIEMSA and observed under a light microscope at x100 magnification to detect the presence of haemoparasites.

Table 1. Geographical characteristics of the study regions.

Agro-ecological zone	Region	Surface area (km^2)	Number of inhabitants	Climate	Average rainfall (mm)	Average altitude (m)	Cartesian coordinates
Guinean high savannah	Adamawa	6761	441,716	Sudanian tropical	950	950	7˚05'06.00"N 13˚12'10.80"E
	East	109,002	835,642	subtropical	1477	650	3˚31'0"N 15˚3'0"E
Western highlands	North west	17,812	1,840,500	savanna	916,6	1550	6˚26'02.40"N 10˚24'00.00"E

Source: Djoufack, 2011 [24].

Table 2. Animal husbandry features of the study regions.

Agro-ecological zone	Region	Type of farming	Cattle	sheep	Goats	Pigs	Poultry	Horse, donkey and camel
Guinean high savannah	Adamawa	Agropastoral and ranching	1,388,755	106,486	87,441	2668	248,744	6608
	East	Agropastoral and ranching	121,143	59,258	79,318	38,779	931,438	1925
Western highlands	North west	Agropastoral and ranching	467,817	240,712	368,190	201,917	756,414	23,247

source: MINEPIA/DEPCS, 2020 [25].

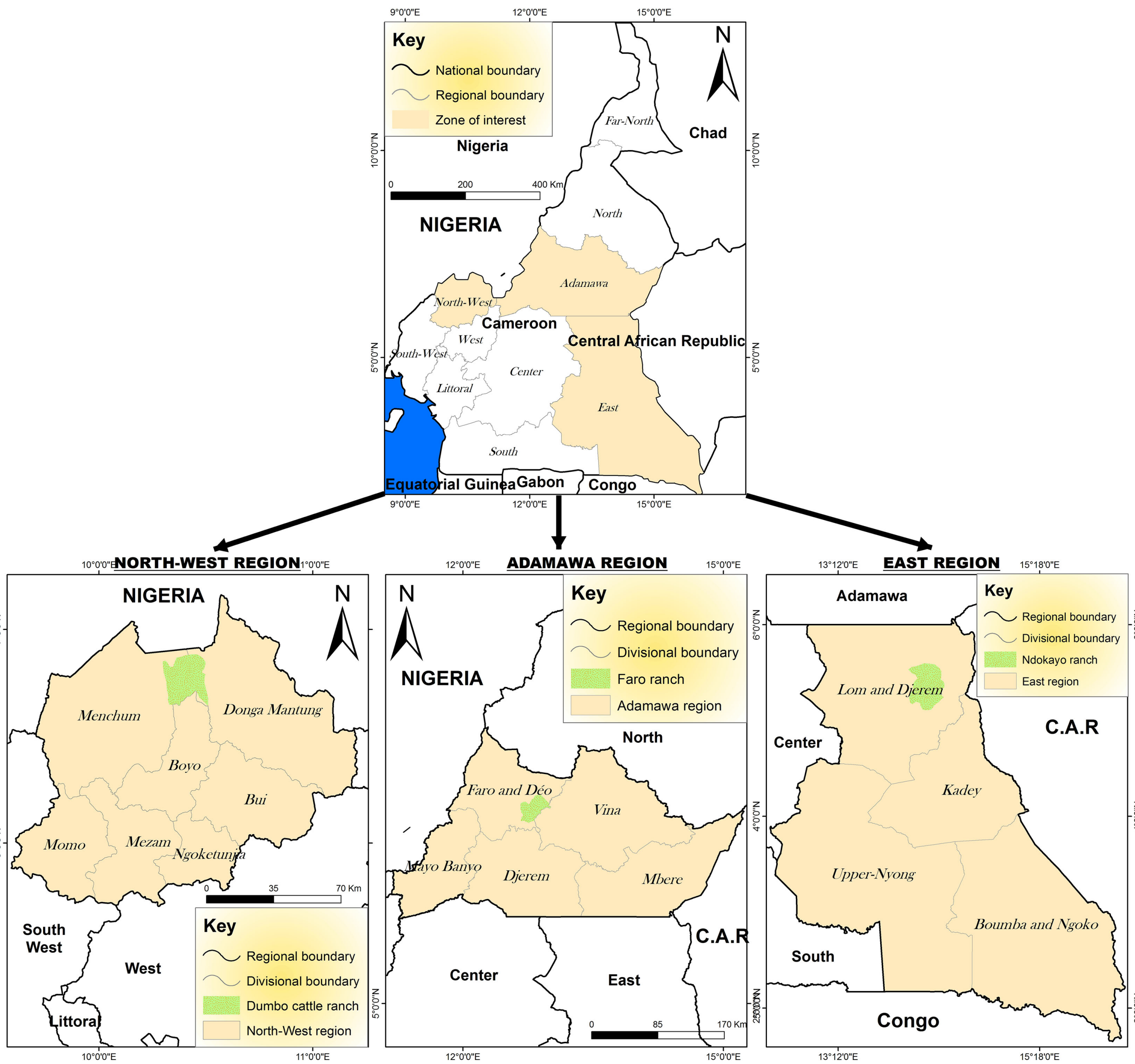

Figure 1. Map of Cameroon showing study regions and administrative divisions within the regions.

Information related to the breed, sex, age and body condition score of the sampled animals were noted. Estimation of ages was done by dental inspection and examination of the horn rings for animals without teeth (especially old/adult females) while the breed of the animals was obtained as previously described [33] [34] [35]. The body condition score was done by assessing the general appearance and palpation of the lumbar region of the animal on a scale of 1 to 5 and further classed into 3 categories: 1 - 2 (poor), 3 (good) and 4 - 5 (very good) as previously described [36].

2.2. Ethical Consideration

Risk assessments of the project were performed by the researchers to avoid hazards to all persons involved in the project. Permission for the study was obtained from the required authorities in Cameroon including the MINEPIA delegations in Adamawa, East and Northwest and North Regions, SODEPA Cameroon (SODEPA Faro, Dumbo and Ndokayo ranches) and the Faculty of Agronomy and Agricultural Sciences of the University of Dschang, Cameroon. The purpose of the study was explained (with the assistance of local community leaders and trusted intermediaries) to cattle professionals with herds in the environs of the SODEPA ranches used in this study. Animals and farms were used in the study after informed consent was given by the owners.

2.3. Data Analysis

The data were analysed using SPSS 21.1 statistical software. Simple percentages were generated and Chi-square test was used to assess the association between factors and the odds-ratios determined for associated risk factors along 95% confidence intervals [26] [37]. The statistical significance was set at $P < 0.05$.

3. Results

3.1. Prevalence of Tick Infestation in Cattle in Cameroon

In this study, of the 742 cattle sampled 566 (76.28%, 95% CI: 73.00 - 79.56) animals were infested with ticks. Locality, age, breed and sex had significant effects ($P < 0.05$) on the prevalence of tick infestation in cattle in the study. Tick infestation was significantly higher in the Adamawa region (99.25%) than in the other 2 regions, in adult animals over 24 months of age (86.34%), in the Simgoud breed (79.87%) and in males (82.49%) (**Table 3**).

Microscopic examination of ticks taken from the cattle sampled revealed the presence of three genera (4 species) of ticks, including *Amblyomma variegatum* (75.09%), *Rhipicephalus microplus* (19.43%), *Rhipicephalus decoloratus* (0.88%) and *Hyalomma marginatum* (0.18%). There are also associations of ticks on the same animal. This was the case for *A. variegatum/R. microplus* (4.06%) and *A. variegatum/H. marginatum* (0.36%) (**Table 4**).

3.2. Prevalence of Tick-Borne Blood Diseases in Cattle in Cameroon

In this study, of the 742 cattle sampled 682 (91.91%, 95% CI) animals were infected with tick-borne blood diseases. Locality, age, and breed had significant effects ($P < 0.05$) on the prevalence of tick-borne disease infection in cattle in the study while sex did not a significant effect ($P > 0.05$). Tick-borne disease infections were significantly higher in the East region (97.31%) than in the other 2 regions, in juvenile animals between 7 to 24 months of age (93.94%) and in the Simgoud breed (93.69%) (Table 5).

Table 3. Prevalence and risk factor for tick infestation of cattle in Cameroon.

Factors	Variables	Number (positive)	Infestation rate % (95% CI)	CT
Region	Adamawa	268 (266)	99.25	*
	East	186 (109)	58.60	
	Northwest	288 (191)	66.32	
Age class (month)	[0 - 6]	90 (52)	57.78	*
	]7 - 24]	264 (179)	67.80	
	[24+[	388 (335)	86.34	
Breed	Goudali	409 (300)	73.35	*
	Simgoud	333 (266)	79.87	
Sex	Male	337 (278)	82.49	*
	Female	405 (288)	71.11	
	Total	742 (566)	76.28	

CT: Contingency test, ns: non-significant, *: significant.

Table 4. Distribution of tick infested cattle according to locality, breed, age and sex in Cameroon.

Factors	Variables	*Amblyomma variegatum*	*Rhipicephalus spp*			*Hyalomma marginatum*	*A.variegatum/ R. microplus*	*A.variegatum/ H. marginatum*	Grand total number of infested cattle (%)
			Rhipicephalus microplus	*Rhipicephalus decoloratus*	Total				
Total		425# (75.09)*	110 (19.43)	5 (0.88)	115 (20.31)	1 (0.18)	23 (4.06)	2 (0.36)	566 (100)
Region	Adamawa	253 (95.11)	1 (0.38)	0 (0)	1 (0.38)	0 (0)	11 (4.14)	1 (0.38)	266 (47)
	East	108 (99.08)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.92)	0 (0)	109 (19.26)
	Northwest	64 (33.51)	109 (57.07)	5 (2.62)	114 (59.69)	1 (0.52)	11 (5.76)	1 (0.52)	191 (33.75)
Age class (month)	[0 - 6]	40 (76.92)	11 (21.15)	0 (0)	11 (21.15)	0 (0)	1 (1.92)	0 (0)	52 (9.19)
	]7 - 24]	131 (73.18)	44 (24.58)	0 (0)	44 (24.58)	0 (0)	4 (2.23)	0 (0)	179 (31.63)
	[24+[	254 (75.82)	55 (16.42)	5 (1.49)	60 (19.91)	1 (0.30)	18 (5.37)	2 (0.60)	335 (59.19)
Breed	Goudali	228 (76)	63 (21)	0 (0)	63 (21)	0 (0)	7 (2.33)	2 (0.67)	300 (53)
	Simgoud	197 (74.06)	47 (17.67)	5 (1.88)	52 (19.55)	1 (0.38)	16 (6.02)	0 (0)	266 (47)
Sex	Male	219 (78.78)	37 (13.31)	1 (0.36)	38 (13.67)	0 (0)	19 (6.83)	2 (0.72)	278 (49.12)
	Female	206 (71.53)	73 (25.35)	4 (1.39)	77 (26.74)	1 (0.35)	4 (1.39)	0 (0)	288 (50.88)

#: number cattle infested by tick, *: proportion (%) of infested cattle.

Microscopic examination of blood smears taken from the cattle sampled revealed the presence of three genera (5 species) of tick-borne blood diseases, including *Babesia bovis* (1.32%), *Babesia major* (0.44%), *Anaplasma marginale* (11.29%), *Anaplasma phagocytophylum* (0.29%) and *Ehrlichia ruminantium* (3.52%). There are also many associations of tick-borne diseases on the same animal. This represents the vast majority of tick-borne blood diseases (79.77%). We also identified *Dermatophilus congolensis* (3.37%), which is not a tick-borne blood disease but is strongly associated with the presence of *Amblyomma variegatum* (Table 6).

Table 5. Prevalence and risk factor for tick-borne blood diseases infection of cattle in Cameroon.

Factors	Variables	Number (positive)	Infection rate % (95% CI)	CT
Region	Adamawa	268 (228)	85.07	*
	East	186 (181)	97.31	
	Northwest	288 (273)	94.79	
Age class (month)	[0 - 6]	90 (78)	86.67	*
	]7 - 24]	264 (248)	93.94	
	[24+[	388 (356)	91.75	
Breed	Goudali	409 (370)	90.46	*
	Simgoud	333 (312)	93.69	
Sex	Male	337 (311)	92.28	ns
	Female	405 (371)	91.60	
	Total	742 (682)	91.91	

CT: Contingency test, ns: non-significant, *: significant.

Table 6. Distribution of tick-borne blood diseases in cattle according to locality, breed, age and sex in Cameroon.

Factors	Variables	*Babesia spp*			*Anaplasma spp*			*Ehrlichia ruminantium*	*Dermatophillus congolensis*	Polymorphism	Grand total number of infested cattle (%)
		Babesia bovis	*Babesia major*	Total	*Anaplasma phagocytophylum*	*Anaplasma marginale*	Total				
Total		9# (1.32)*	3 (0.44)	12 (1.76)	2 (0.29)	77 (11.29)	79 (11.58)	24 (3.52)	23 (3.37)	544 (79.77)	682 (100.00)
Region	Adamawa	9 (3.95)	2 (0.88)	11 (4.83)	2 (0.88)	15 (6.58)	17 (7.46)	8 (3.51)	18 (7.89)	174 (76.32)	228 (33.43)
	East	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	15 (8.29)	15 (8.29)	4 (2.21)	0 (0.00)	162 (89.50)	181 (26.54)
	Northwest	0 (0.00)	1 (0.37)	1 (0.37)	0 (0.00)	47 (17.22)	47 (17.22)	11 (4.03)	6 (2.20)	208 (76.19)	273 (40.03)
Age class (month)	[0 - 6]	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	8 (10.26)	8 (10.26)	0 (0.00)	2 (2.56)	68 (87.18)	78 (11.44)
	]7 - 24]	1 (0.40)	2 (0.81)	3 (1.21)	0 (0.00)	11 (4.44)	11 (4.44)	4 (1.61)	9 (3.63)	221 (89.11)	248 (36.36)
	[24+[	8 (2.25)	1 (0.28)	9 (2.53)	2 (0.56)	58 (16.29)	60 (16.85)	19 (5.34)	13 (3.65)	255 (71.63)	356 (52.20)
Breed	Goudali	7 (1.89)	0 (0.00)	7 (1.89)	1 (0.27)	40 (10.81)	41 (11.08)	17 (4.59)	20 (5.41)	285 (77.03)	370 (54.25)
	Simgoud	2 (0.64)	3 (0.96)	5 (1.6)	1 (0.32)	37 (11.86)	38 (12.18)	6 (1.92)	4 (1.28)	259 (83.01)	312 (45.75)
Sex	Male	3 (0.96)	2 (0.64)	5 (1.6)	1 (0.32)	36 (11.58)	37 (11.90)	10 (3.22)	13 (4.18)	246 (79.10)	311 (45.60)
	Female	6 (1.62)	1 (0.27)	7 (1.89)	1 (0.27)	41 (11.05)	42 (11.32)	13 (3.50)	11 (2.96)	298 (80.32)	371 (54.40)

#: number of cattle infected by haemoparasites, *: proportion (%) of infected cattle.

4. Discussion

The prevalence of ticks and TBD has been widely documented in tropical environments. This aspect is addressed in several ways by various methods, namely blood sampling and germ detection or molecular analysis of the ticks themselves. The results obtained on prevalence as a function of locality significantly corroborate those of [38], who argue that the prevalence of each tick species in its geographical distribution is conditioned by biomes and specific environmental conditions such as temperature. It is normal that, depending on the environmental conditions, there should be various adaptations of species.

4.1. *Amblyomma variegatum*

The results obtained from the frequency of this tick in the different regions of 75.09% show the abundance of this tick and are similar to those obtained from 46.3% to 73.8% [39]-[45]. These same authors found that it is practically the most widespread in several African countries. However, [46] found that the genus *Rhipicephalus* (80.60%) was more important than *Amblyomma* (19.31%). This tick thrives in the warmer regions of Africa. We note that it is less significant in the north-west, which is a mountainous area with low average annual temperatures compared with the other two regions.

4.2. *Rhipicephalus microplus*

The results obtained for this tick are 19.43% overall. However, it is very prevalent in the North West region, where 57.07% of animals are infested with this species, in contrast to the other two regions, where it was only mentioned very rarely. This prevalence is not far from the results obtained by numerous authors in several countries, including Cameroon [41] [43], which vary from 15.6% to 24.11%. This confirms the presence of this highly invasive species in Cameroon [47].

4.3. *Hyalomma marginatum*

The results obtained from the presence of this tick, concentrated in the north-west with a very low prevalence of around 0.18%, are similar to those obtained from several studies which only mention its presence without mentioning a precise prevalence. These include [39] [48] [49]. However, other authors have given prevalence ranging from 1.8% to 13.8% [45] [50] [51].

4.4. *Rhipicephalus decoloratus*

The results we obtained (0.88%) were founded only in the north-west among adults. However, several studies have mentioned its presence (20.1% to 50.6%) in various regions of Africa [38] [44] [52] [53]. Our results are higher than obtained in north-west Cameroon (0.4%) by [39].

The results obtained in the different regions mentioning the presence of babesiosis, anaplasmosis, richetsiosis and dermatophilosis are caused by several germs sometimes associated with each other on the same animal.

4.5. Babesiosis

We encountered two germs, *Babesia bovis* (1.3%) and *Babesia major* (0.44%), especially in the East region. The results are not very far from those obtained in small ruminants (2.9%) in the Adamawa region [41]. This disease is usually mentioned in the records of the veterinary services in all regions where cattle are reared.

4.6. Anaplasmosis

We encountered two germs, *Anaplasma marginale* (11.29%) and *Anaplasma phagocytophilum* (0.29%), respectively in the three regions for the former and only in Adamawa for the latter. The prevalence of *Anaplasma marginale* is similar to the results obtained for small ruminants (9.1%) in Adamawa [41]. This species is the most pathogenic of its genus [54].

4.7. *Ehrlichia ruminantium*

The results obtained for the prevalence of around 3.52% are different from those obtained in a study carried out in Benin using molecular analysis of ticks, which revealed the germ with an overall prevalence in ticks of 10.8% [49] and 28.4% [55]. This may be due to the different techniques used, as we worked on the animals and not on the ticks. In addition, there is a correlation between the presence of this germ and the environment.

5. Conclusion

This study was carried out to determine the prevalence and intensity of tick infestation and haemoparasites in cattle within and around the SODEPA ranches in the Guinean high savannah agro-ecological zone and in the western highland agro-ecological zone of Cameroon reveals the presence of three ticks genus (4 species): *Amlyomma variegatum*, *Rhipicephalus microplus*, *Hyalomma marginatum* and *Rhipicephalus decoloratus*. The following tick-borne diseases were also identified: *Babesia bovis*, *Babesia major*, *Anaplasma marginale*, *Anaplasma phagocytophylum and Ehrlichia ruminantium.* We also identified *Dermatophilus congolensis* which is not a tick-borne disease but associated with Amblyomma presence. There is a significant dependence between the prevalence of ticks and locality, sex, breed and age. Similarly, there was a dependence on the prevalence of tick-borne diseases and locality, breed and age. On the other hand, there was no dependence between tick-borne diseases and the sex of the animal. The perspective of this study is to examine the implementation of a tick and haemoparasite control mechanism that is both animal welfare-friendly and environmentally friendly.

Authors' Contributions

HH conceptualised the study under the direction of FM, and he collected data and wrote the first draft of the manuscript. AFE contributed to the final manuscript. FM, RA, NAJ and BM supervised HH.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Chabi Toko, R. (2016) Place de l'élevage bovin dans l'économie rurale des Peuls du Nord Bénin. Ph.D. Thesis, Université de Liège, Liège.

[2] Desiere, S., Niragira, S. and D'Haese, M. (2015) Cow or Goat? Population Pressure and Livestock Keeping in Burundi. *Agrekon*, **54**, 23-42. https://doi.org/10.1080/03031853.2015.1084941

[3] Klapwijk, C.J., Schut, M., van Asten, P.J.A., Vanlauwe, B., Giller, K.E. and Descheemaeker, K. (2019) Micro-Livestock in Smallholder Farming Systems: The Role, Challenges and Opportunities for Cavies in South Kivu, Eastern DR Congo. *Tropical Animal Health and Production*, **52**, 1167-1177. https://doi.org/10.1007/s11250-019-02112-9

[4] Food and Agriculture Organization (2009) Livestock Keepers—Guardians of Biodiversity. Animal Production and Health Paper. No. 167. Rome. http://fao.org/docrep/fao/012/i1034e/i1034e.pdf

[5] INS (2019) Annuaire statistique du Cameroun, Chapitre 14: Elevage et pêche 209-219.

[6] De Clercq, E.M., Estrada-Peña, A., Adehan, S., Madder, M. and Vanwambeke, S.O. (2013) An Update on Distribution Models for Rhipicephalus (Boophilus) Microplus in West Africa. *Geospatial Health*, **8**, 301-308. https://doi.org/10.4081/gh.2013.75

[7] Parola, P. and Raoult, D. (2001) Ticks and Tick-Borne Bacterial Disease in Humans: An Emerging Infection Threat. *Clinical Infectious Diseases*, **32**, 897-928.

[8] Dougnon, T.J., Adéhan, S., Houessionon, J. and Farougou, S. (2015) *In vitro* Effect of the Ethanolic Extract of *Tephrosia vogelii* on *Rhipicephalus sanguineus* in Abomey-Calavi. *Avicenna Journal of Phytomedicine*, **5**, 247-259.

[9] Snorre, S. (2020) Haemoparasites-Challenging and Wasting Infections in Small Ruminants: A Review. *Animals*, **10**, Article 2179. https://doi.org/10.3390/ani10112179

[10] Collot, M.E. (2010) La babésiose bovine, Une zoonose à risque pour l'homme. Master's Thesis, Université Henri Poincaré, Sydney.

[11] Rana, M.S., Lee, S.Y., Kang, H.J. and Hur, S.J. (2019) Reducing Veterinary Drug Residues in Animal Products: A Review. *Food Science of Animal Resources*, **39**, 687-703. https://doi.org/10.5851/kosfa.2019.e65

[12] Kandé, S. (2014) Évaluation de la résistance des tiques Rhipicephalus (Boophilus) microplus aux acaricides dans les zones d'introduction en Afrique de l'Ouest (Bénin,

Burkina Faso et Côte d'Ivoire). Master's Thesis, Université Polytechnique de Bobo-Dioulasso-Institut de développement Rural, Dioulasso.

[13] Rodriguez-Vivas, R., Jonsson, N. and Bhushan, C. (2018) Stratégies de contrôle des tiques *Rhipicephalus microplus* dans un monde de résistance conventionnelle aux acaricides et aux lactones macrocycliques. *Parasitology Research*, **117**, 3-29.

[14] Adehan, S.B., Guedou, M.S.E., Adakal, H., Gbaguidi, A.M., Dossou-Gbete, G.S.O., Adehan, R., Farougou, S., Mensah, G.A., Madder, M. and De Clercq, E.M. (2010) Document Technique d'information: Perception des stratégies de contrôle des tiques par les éleveurs au Bénin. https://doi.org/10.13140/RG.2.2.28306.71360

[15] Huber, K., Lefrancois, T., Cardinale, E., Esnault, O., Hue, T., Pannequin, M. and Stachurski, F. (2015) Impacts majeurs des tiques en santé animale en Outre-mer. Journée thématique Tiques et maladies à tiques: Impacts en santé humaine et vétérinaire, Centre National d'Expertise sur les Vecteurs, May 2015, Maison-Alfort, France.

[16] Sungirai, M., Doreen Zandile, M., De Clercq, P. and Madder, M. (2015) Communal Farmers' Perceptions of Tick-Borne Diseases Affecting Cattle and Investigation of Tick Control Methods Practiced in Zimbabwe. *Ticks and Tick-Borne Diseases*, **7**, 1-9. https://doi.org/10.1016/j.ttbdis.2015.07.015

[17] Alary, V., Duteurtre, G. and Faye, B. (2011) Élevages et sociétés: Les rôles multiples de l'élevage dans les pays tropicaux. *INRAE Productions Animales*, **24**, 145-156. https://doi.org/10.20870/productions-animales.2011.24.1.3246

[18] De Meneghi, D., Stachurski, F. and Adakal, H. (2016) Experiences in Tick Control by Acaricide in the Traditional Cattle Sector in Zambia and Burkina Faso: Possible Environmental and Public Health Implications. *Frontiers in Public Health*, **4**, Article 207808. https://doi.org/10.3389/fpubh.2016.00239

[19] Biguezoton, S.A. (2017) Invasion biologique et écologie de la santé vétérinaire: Le cas des communautés de tiques et pathogènes associés au Bénin et au Burkina Faso à l'heure de leur invasion par la tique du bétail Rhipicephalus (Boophilus) microplus. Master's Thesis, Université de Montpellier, Montpellier.

[20] Gérard, D., Fontenille, D. and Vincent, R. (2017) Entomologie médicale et vétérinaire. pp. 1-688.

[21] Mebanga Sassa, A., Agnem Etchike, C., Gambo, H. and Njan Nloga, A. (2016) Inventaire et prévalence des tiques du bétail dans les élevages de l'Adamaoua au Cameroun. *Revue Africaine de Santé et de Productions Animales*, **12**, 15-19.

[22] Maho, A. and Mopate, Y.L. (2007) Dominantes pathologiques des ruminants et des monogastriques domestiques dans la zone soudanienne du Tchad. *Actes du colloque*, Garoua, 27-31 mai 2007, 12.

[23] Zachée, B., Mahamat, O., Saboun, M. and Julius, A.N. (2020) Prevalence, Intensity and Risk Factors of Tick Infestation of Cattle in N'djamena Chad. *International Journal of Veterinary Sciences and Animal Husbandry*, 5, 139-146. http://www.veterinarypaper.com/archives/2020/5/4/C

[24] Djoufack, V. (2011) Etude multi-échelles des précipitations et du couvert végétal au Cameroun: Analyses spatiales, Tendances temporelles, Facteurs climatiques et anthropiques de variabilité du NDVI. Master's Thesis, Université de Bourgogne, Dijon.

[25] MINEPIA (2020) Situation des productions et des importations du sous-secteur élevage, Pêches et industries animales en 2019. Division des Etudes, De la Planification, De la Coopération et des Statistiques.

[26] Lorusso, V., Picozzi, K., de Bronsvoort, B.M.C., Majekodunmi, A., Dongkum, C.,

Balak, G., Igweh, A. and Welburn, S.C. (2013) Ixodid Ticks of Traditionally Managed Cattle in Central Nigeria: Where Rhipicephalus (Boophilus) Microplus Does Not Dare (yet?). *Parasites & Vectors*, **6**, Article No. 171. https://doi.org/10.1186/1756-3305-6-171

[27] Kaiser, M.N. (1987) Ethiopia-Report on Tick Taxonomy and Biology. FAO-UN. AG: DP/ETH/83/023.

[28] Hoogstraal, H. (1956) African Ixodoidea, Ticks of the Sudan. Department of the US Navy Bureau of Medicine and Surgery. https://doi.org/10.5962/bhl.title.6870

[29] Morel, P.C. (1980) Study on Ethiopia Ticks. Republic of France, Ministry of Foreign Affairs, French Veterinary Mission in Ethiopia, Addis Ababa, 15-183.

[30] Mathysse, J.G. and Colobo, M.H. (1987) The Ixodid Ticks of Uganda: Entomological Society of America, College Park, Maryland.

[31] Walker, A.A., Bouatour, A. and Camicasetal, J.L. (2003) Ticks of Domestic Animals in Africa: A Guide to Identiication of Species. The University of Edinburgh, Edinburgh.

[32] Meddour, B.K. and Meddour, A. (2006) Clés d'identification des Ixodina (Acarina) d'Algérie. *Sciences et Technologies*, **4**, 32-42.

[33] Blench, R. (1999) Traditional Livestock Breeds: Geographical Distribution and Dynamics in Relation to the Ecology of West Africa. Working Paper 122, Overseas Development Institute, London.

[34] MINEPIA (2002) La stratégie sectorielle de l'élevage, Des pêches et industries animales. In: Yaounde, D.A., Eds., *Cabinet Management* 2000 *Minepia*, Ministry of Livestock, Fisheries and Animal Industries, Yaounde, 93.

[35] Fassi, F.A. (2006) Collecte et maturation des ovocytes bovins: Effet de l'état nutritionnel sur le rendement et la qualité des ovocytes. Master's Thesis, Institut Agronomique et Vétérinaire Hassan II, Rabat.

[36] Natumanya, R., Owiny, D. and Kugonza, R. (2008) The Potential of Ankole Cattle Abattoir Ovaries for *in vi*tro Embryo Production. *Asian Journal of Animal and Biomedical Sciences*, **3**, 1819-4214.

[37] Thrusfield, M. (2007) Veterinary Epidemiology. 3rd Edition, Blackwell Science Ltd, Oxford.

[38] Bouchard, C., Dibernardo, A., Koffi, J., Wood, H., Leighton, P.A. and Lindsay, L.R.N. (2019) Increased Risk of Tick-Borne Diseases with Climate and Environmental Changes. *Canada Communicable Disease Report*, **45**, 81-89. https://doi.org/10.14745/ccdr.v45i04a02

[39] Awa, D.N. (1997) Serological Survey of Heart-Water Relative to the Distribution of the Vector *Amblyomma variegatum* and Other Tick Species in North Cameroon. *Veterinary Parasitology*, **68**, 165-173. https://doi.org/10.1016/S0304-4017(96)01058-8

[40] Molia, S., Frebling, M., Vachiéry, N., Pinarello, V., Petitclerc, M., Rousteau, A., Lefrançois, T., *et al.* (2008) *Amblyomma variegatum* in Cattle in Marie Galante, French Antilles: Prevalence, Control Measures, and Infection by *Ehrlichia ruminantium*. *Veterinary Parasitology*, **153**, 338-346. https://doi.org/10.1016/j.vetpar.2008.01.046

[41] Sassa, A.M., Etchike, C.A., Gambo, H. and Nloga, A.N. (2014) Inventaire et prévalence des tiques du bétail dans les élevages de l'Adamaoua au Cameroun. *Revue Africaine de Santé et de Productions Animales*, **12**, 15-19.

[42] Amoia, C.F.A.N. (2015) Diagnostic des pratiques de lutte anti-tique et distribution

spatiale de la tique invasive Rhipicephalus (Boophilus) microplus (Canestrini, 1888) en Côte d'Ivoire. Master's Thesis, Université Nangui Abrogoua, Abidjan.

[43] Silatsaa, B.A., Simo, G., Githaka, N., Mwaura, S., Kamga, R.M., Oumarou, F., Keambou, C., Bishop, R.P., Djikeng, A., Kuiate, J.R., Njiokou, F. and Pelle, R. (2019) A Comprehensive Survey of the Prevalence and Spatial Distribution of Ticks Infesting Cattle in Different Agro-Ecological Zones of Cameroon. *Parasites & Vectors*, **12**, Article No. 489. https://doi.org/10.1186/s13071-019-3738-7

[44] Wondimu, A. and Bayu, Y. (2021) Identification and Prevalence of Ixodid Ticks of Cattle in Case of Haramaya Eastern Hararghe, Ethiopia. *Veterinary Medicine International*, **2021**, Article ID: 8836547. https://doi.org/10.1155/2021/8836547

[45] Nimo-Paintsil, S.C., Mosore, M., Addo, S.O., Lura, T., Tagoe, J., Ladzekpo, D. and Diclaro, J.W. (2022) Ticks and Prevalence of Tick-Borne Pathogens from Domestic Animals in Ghana. *Parasites & Vectors*, **15**, Article No. 86. https://doi.org/10.1186/s13071-022-05208-8

[46] Sylla, I., Kone, M., Toure, A., Koffi, M.N.G. and Koukougnon, D. (2022) Identification des tiques parasites chez les bovins à Daloa. *Agronomie Africaine*, **34**, 45-56.

[47] Silatsaa, B.A., Kuiateb, J.R., Njiokou, F., Simo, G., Feussome, J.M.K., Tunrayo, A., Amzati, G.S., Bett, B., Bishop, R., Githaka, N., Opiyo, S.O., Djikeng, A. and Pelle, R. (2019) A Countrywide Molecular Survey Leads to a Seminal Identification of the Invasive Cattle Tick Rhipicephalus (Boophilus) Microplus in Cameroon, A Decade after It Was Reported in Cote d'Ivoire. *Ticks and Tick Borne Disease*, **10**, 585-593. https://doi.org/10.1016/j.ttbdis.2019.02.002

[48] Bayemi, P.H. (1991) Seasonnal Dynamics of Tick Infestations (ixodidea) in Cattle Sold in the Area of Yaounde, Cameroon. *Revue d'élevage et de médecine vétérinaire des pays tropicaux*, **44**, 309-318. https://doi.org/10.19182/remvt.9172

[49] Farougou, S., Adakal, H., Biguezoton, A.S. and Boko, C. (2012) Prévalence de l'infection d'*Amblyomma variegatum* par *Ehrlichia ruminantium* dans les élevages extensifs du Bénin. *Revue de Médecine Vétérinaire*, **163**, 261-266.

[50] Toure, A., Diaha, C.A., Sylla, I. and Kouakou, K. (2014) Récente recomposition des populations de tiques prévalent en Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, **8**, 566-578. https://doi.org/10.4314/ijbcs.v8i2.15

[51] Peter, S.G., Kariuki, H.W., Aboge, G.O., Gakuya, D.W., Maingi, N. and Mulei, C.M. (2021) Prevalence of Ticks Infesting Dairy Cattle and the Pathogens They Harbour in Smallholder Farms in Peri-Urban Areas of Nairobi, Kenya. *Veterinary Medicine International*, **2021**, Article ID: 9501648. https://doi.org/10.1155/2021/9501648

[52] Sado Yousseu, F., Simo Tchetgna, H., Kamgang, B., Djonabaye, D., McCall, P.J., Ndip, R.N. and Wondji, C.S. (2022) Infestation Rates, Seasonal Distribution, and Genetic Diversity of Ixodid Ticks from Livestock of Various Origins in Two Markets of Yaoundé, Cameroon. *Medical and Veterinary Entomology*, **36**, 283-300. https://doi.org/10.1111/mve.12589

[53] Lontsi-Demano, M., Ngnindji-Youdje, Y., Laroche, M., Bamou, R., Talom, A.D., Abah, S. and Tchuinkam, T. (2020) Cattle Trading Favors the Introduction and Establishment of the Invasive Tick Rhipicephalus (Boophilus) Microplus in Menoua Division, West Region of Cameroon. *Journal of Entomology and Zoology Studies*, **8**, 207-214.

[54] Said, M.B., Belkahia, H. and Messadi, L. (2018) *Anaplasma* spp. in North Africa: A Review on Molecular Epidemiology, Associated Risk Factors and Genetic Characteristics. *Ticks and Tick-Borne Diseases*, **9**, 543-555. https://doi.org/10.1016/j.ttbdis.2018.01.003

[55] Esemu, S.N., Besong, W.O., Ndip, R.N. and Ndip, L.M. (2013) Prevalence of *Ehrlichia ruminantium* in Adult *Amblyomma variegatum* Collected from Cattle in Cameroon. *Experimental and Applied Acarology*, **59**, 377-387. https://doi.org/10.1007/s10493-012-9599-9